

# Training Range Environmental Evaluation and Characterization System (TREECS)

Environment, Energy, Security, and  
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US Army Corps of Engineers  
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# ***TREECS Problem Statement***

- Residues and disturbances from range operations can impact the environment, including human and ecological health. Such impacts can impact environmental compliance and range sustainment.
- Army live fire training and test ranges have unique environments in which low-order and unexploded ordnance (dud munitions) are likely to cause random and highly uncertain sources of MC contamination.
- ***An assessment tool is needed to forecast if, when, and at what level MC concentrations in off-range media (groundwater, surface water, and sediment) may exceed protective health benchmarks.***



# ***TREECS Solution / Approach***

Training Range Environmental Evaluation and Characterization System (TREECS) is a client-based system that provides forecasts of Munitions Constituents (MC) fate on and off range based on munitions use on range.

## **Development Approach:**

Formulate and couple screening level MC fate/transport-transformation-sequestration models in an integrated framework for fast assessments with a minimal amount of user input.

## **Partners:**

PNNL, AEC, CHPPM, ITL, and EL

<http://el.erdcl.usace.army.mil/treecs/>



# ***TREECS Components***

- Framework for Tier 1 and 2 assessments
- Constituent databases
- Health Benchmark database
- Munitions database
- MC residual mass loading module based on munitions use
- GIS module
- Hydro-geo-characteristics toolkit (HGCT) for estimating input parameters
- Models for soil, surface water, vadose zone, and groundwater
- Simplified user input interfaces for models (GUIs)
- Viewers for results
- Sensitivity and uncertainty module for Tier 2 assessments



# TREecs Main Screen




**TREecs - Training Range Environmental Evaluation and Characterization System**




File References Web Data Tools Websites Options Help




Installation/AOI Description Tier Analysis Selection Site Conditions DoD Target Health Benchmarks Inputs Execute Uncertainty View Results

Installation name:   AOI name:

Installation description:  AOI description:







Shapes

☒ MyAoi

☒ soilsf\_p\_ga620

☒ soilsf\_l\_ga620

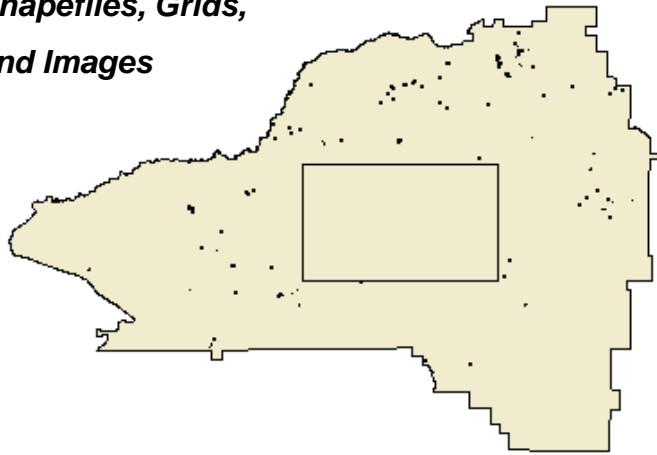
☒ soilsa\_a\_ga620

☒ soilmu\_p\_ga620


☒ soilmu\_l\_ga620

☐ soilsa\_p\_ga620

**Shapefiles, Grids,  
and Images**



GIS Module





# ***GIS Functions/Tools***



- For opening individual GIS files



- For saving individual GIS files



- For resampling a grid



- For zooming into an area in the workspace



- For zooming out of an area in the workspace



- For panning in the workspace



- For creating a rectangular AOI shapefile in the workspace



- For creating a polygon AOI shapefile in the workspace



- For measuring length and area in the workspace



- For converting a shapefile to a grid



- For extracting a subset of a grid



- For creating slope grid from DEM and performing simple arithmetic operations on a grid





# ***Hydro-Geo-Characteristics Toolkit (HGCT)***

- To aid the user in determining input variables required by TREECS models
  - ▶ Soil Properties
  - ▶ Soil erosion rate
  - ▶ Hydrology (infiltration, runoff, ET, etc.)
  - ▶ Darcy velocity
- Allows *point* (single value) and *spatially-varying* composite estimates
- Spatial option requires use of GIS module in TREECS or externally developed map files (grids)



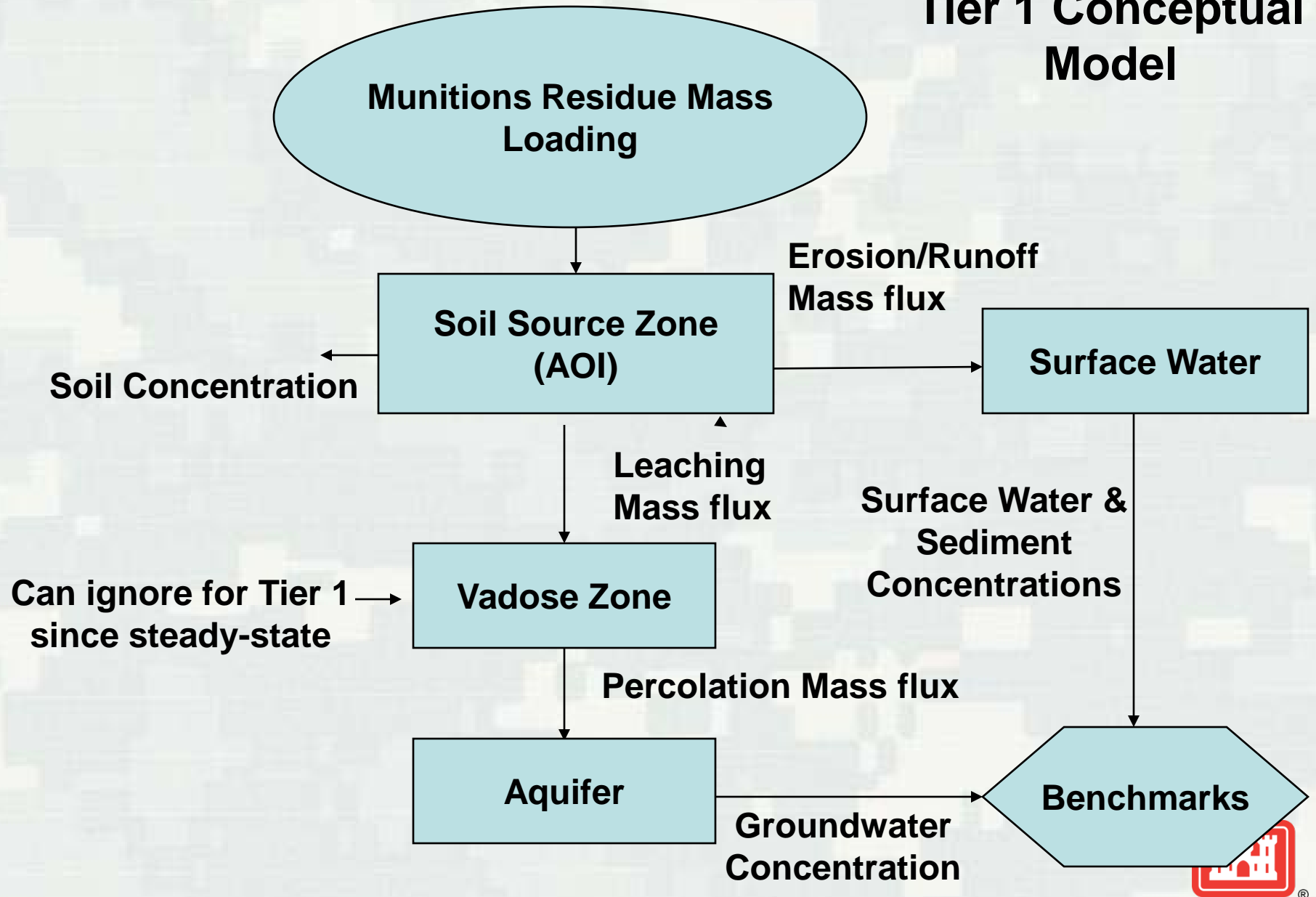


# ***Tiered Approach***

- Tier 1 (screening)
  - ▶ Steady-state, no degradation, worse case, highly conservative
  - ▶ Requires little data
  - ▶ Can be applied very quickly
  - ▶ Indicates whether a problem could ever potentially exist; if so, proceed to Tier 2
  
- Tier 2 (more comprehensive)
  - ▶ Time-varying, much more realistic and accurate
  - ▶ Requires more data
  - ▶ Requires more time to set up and apply, but still can be done relatively quickly
  - ▶ Can be used to determine when benchmark exceedence may occur
  - ▶ Useful for evaluating range management strategies



# Tier 1 Conceptual Model



# ***Tier 1 Model Primary Assumptions***

- Area of Interest (AOI) is homogeneous
- Constant loading of MC into impact area (could possibly add firing points later)
- Soil concentrations are at steady-state
- No decay/degradation or volatilization, except for surface water volatilization
- No losses between the AOI and receiving surface water



## ***Tier 1 Modules***

- MC mass loading based on munitions use
- Constituent databases
- Benchmark database
- Hydro-geo-characteristics toolkit (HGCT) for estimating input parameters (covered in separate session)
- GIS module for viewing of spatial info and for use in developing gridded info for HGCT spatial (covered in separate session)
- Steady-state soil model
- MEPAS Aquifer model with inputs simplified for Tier 1
- RECOVERY surface water model with inputs simplified for Tier 1
- Viewers for results



# ***Constituent Database Module (Constituent Selection)***

- Available Databases
  - ▶ FRAMES
  - ▶ Risk Assessment Information System (RAIS)
  - ▶ Army Range Constituent Database
  - ▶ User Defined (build from Con DB editor tool starting with a copy of the FRAMES (FUI) DB)
- For selecting MC and their properties
- Contains physical/chemical properties for MC and other contaminants
- Can change property values within the TREECS application, but it does not change database value



# Constituent Selection

**TREECS - Training Range Environmental Evaluation and Characterization System (T1APH\_SP.trp)**

File References Web Data Tools Websites Options Help

Installation/AOI Description Tier Analysis Selection **Site Conditions** DoD Target Health Benchmarks Inputs Execute Uncertainty View Results

**Constituent Selection** Operational Inputs

Select the constituent database to use:

- ☐ FRAMES Constituent Database
- ☐ Army Range Constituent Database
- ☐ Risk Assessment Information System (RAIS)
- ☒ User Defined Constituent Database

**Select Database**

Available constituents (CASRN):

- 1,1 dichloroethylene (75354)
- vinylidene chloride (75354)
- 1,1,1,2-tetrachloroethane (630206)
- 1,1,1-trichloroethane (71556)
- methyl chloroform (71556)
- 1,1,2,2-tetrachloroethane (79345)

**Select MC**

Select

Info

Search: Find /Find Next...

☐ List by CASRN (name)

User-defined constituent database:

C:\Program Files\TREECS\Databases\treec Browse for database

Load/Reload Database

Currently selected constituents (CASRN):

- rdx (121824)
- trt (118967)
- lead (7439921)
- copper (7440508)
- potassium perchlorate (7778747)

**View MC Properties**

Remove

Info

**Can use a user defined database (Create under Tools)**



# MC Residue Mass Loading Module (Operational Inputs)

TRECS - Training Range Environmental Evaluation and Characterization System (T1APH\_SP.trp)

File References Web Data Tools Websites Options Help

Installation/AOI Description Tier Analysis Selection Site Conditions DoD Target Health Benchmarks Inputs Execute Uncertainty View Results

Constituent Selection Operational Inputs

Type of loading to be estimated:

- ☒ Impact Zone
- ☐ Firing Point

Select the munitions database to use:

- ☐ Default munitions database
- ☒ User defined munitions database

User defined munitions database:  
C:\Program Files\TRECS\Data

Load/Reload Database

Munitions master list:

AP Hill B584 (NSN: 0001) (DODIC: B584)
AP Hill L601 (NSN: 0002) (DODIC: L601)
AP Hill L594 (NSN: 0003) (DODIC: L594)
AP Hill H975 (NSN: 0004) (DODIC: H975)
AP Hill D544 (NSN: 0005) (DODIC: D544)

Select

Search:

Find/Find Next

Munitions used at this site/range:

AP Hill D544 (NSN: 0005) (DODIC: D544)
AP Hill B546 (NSN: 0007) (DODIC: B546)
AP Hill B470 (NSN: 0008) (DODIC: B470)
AP Hill B542 (NSN: 0009) (DODIC: B542)
AP Hill B103 (NSN: 0010) (DODIC: B103)

Remove

Detailed Info

Munitions usage information:

Munition: AP Hill D544 (NSN: 0005) (DODIC: D544)

Starting year of simulation:

Rounds fired per year: 861

Dud percentage: 0

Low order percentage: 2

High order percentage: 98

Percentage of duds sympathetically detonated: 0

Sympathetic dud yield percentage: 100

Low order yield percentage: 50

High order yield percentage: 100

Can use a User Defined munitions database

Constant in Tier 1

Provided by user

Help

Constituent masses are summed across PEP, bulk, and inert material types and used as the total mass available at the impact or firing point. It is assumed that the fraction of summed constituent mass consumed in the yield is vaporized and is not available as residue.

Pulled from  
MIDAS  
Extract DB

Provided by  
user



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# MC Residue Mass Loading

$$L_{i,k} = \sum_{j=1}^{j=n} \left\{ N_{j,k} M_{i,j} \left[ \frac{LO_{j,k} (100 - Y_{LOj,k}) + HO_{j,k} (100 - Y_{HOj,k}) + DUD_{j,k} SYM_{j,k} (100 - Y_{SYMj,k})}{100} \right] \right\}$$

$L_{i,k}$	= Loading for constituent I for year k, g/yr
$DUD_{j,k}$	= percent of duds for munitions item j for year k
$HO_{j,k}$	= percent of high order detonations for munitions item j for year k
$LO_{j,k}$	= percent of low order detonations for munitions item j for year k
$M_{i,j}$	= mass of constituent i in munitions item j delivered to impact area, g/item
$N_{j,k}$	= number of munitions item j fired for year k
$n$	= total number of munitions items used at AOI
$SYM_{j,k}$	= percent of sympathetic detonation of duds for munitions item j for year k
$Y_{HOj,k}$	= percent yield of munitions item j due to high order detonation for year k
$Y_{LOj,k}$	= percent yield of munitions item j due to low order detonation for year k
$Y_{SYMj,k}$	= percent yield of munitions item j due to sympathetic detonation for year k



# ***DoD Protective Health Benchmarks Database Construct***

- Media and end point
  - ▶ Soil: human and eco (grayed out since no values currently)
  - ▶ Groundwater: human
  - ▶ Surface water: eco and human
  - ▶ Surface water sediments: eco



# Benchmark Database Module

TRECS - Training Range Environmental Evaluation and Characterization System (T1APH\_SP.trp)

File References Web Data Tools Websites Options Help

Installation/AOI Description Tier Analysis Selection Site Conditions DoD Target Health Benchmarks Inputs Execute Uncertainty View Results

Select from the benchmark options below:

- ☒ DoD Target Health Benchmarks
- ☐ User-defined benchmark database

Can use the DoD DB or a User Defined DB

	Constituent Name	Constituent CASRN	Media	Receptor	Value	Unit
▶	RDX	121-82-4	surfacewater-mari...	Eco	5000	ug/L
	RDX	121-82-4	sediment-marine	Eco	0.026	mg/kg
	RDX	121-82-4	surfacewater-fresh	Eco	190	ug/L
	RDX	121-82-4	sediment-fresh	Eco	0.026	mg/kg
	RDX	121-82-4	surfacewater-fresh	Human	0.61	ug/L

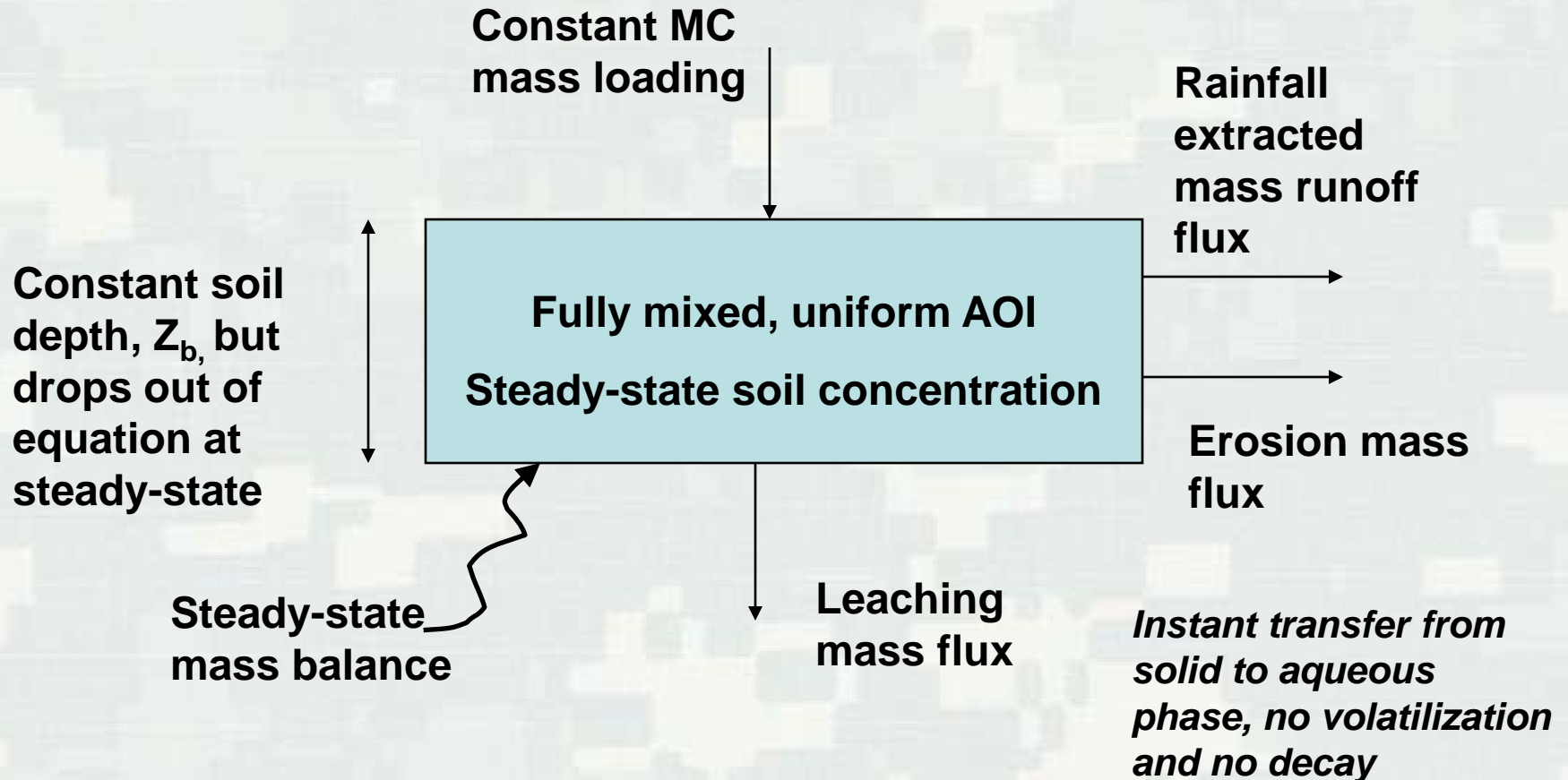
☐ Ecological Surface Water/Sediment is marine (as opposed to freshwater)

Sediment TOC:  fraction

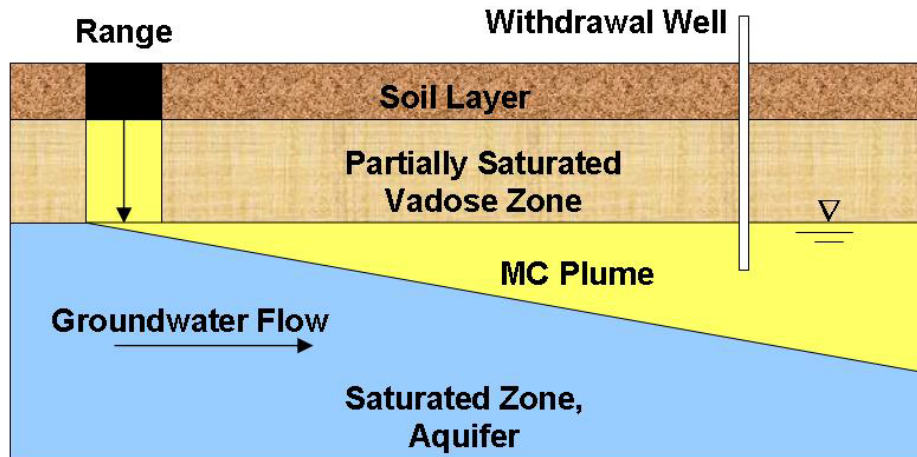
Soil TOC:  fraction



# ***Tier 1 Soil Model***



# ***Aquifer Model for Tier 1 – MEPAS Aquifer with less inputs (prescribed inputs)***

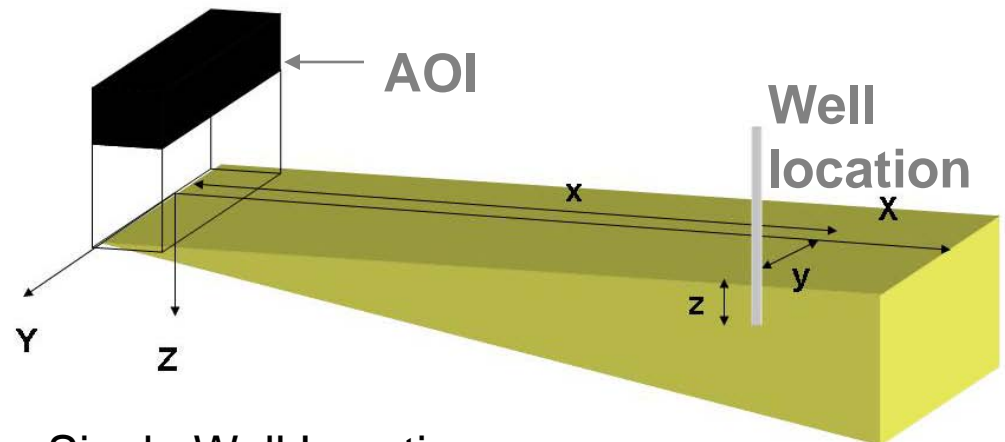


**AOI length and width  
are input in Soil MUI**

**MEPAS coordinates**

## **Conceptual Model**

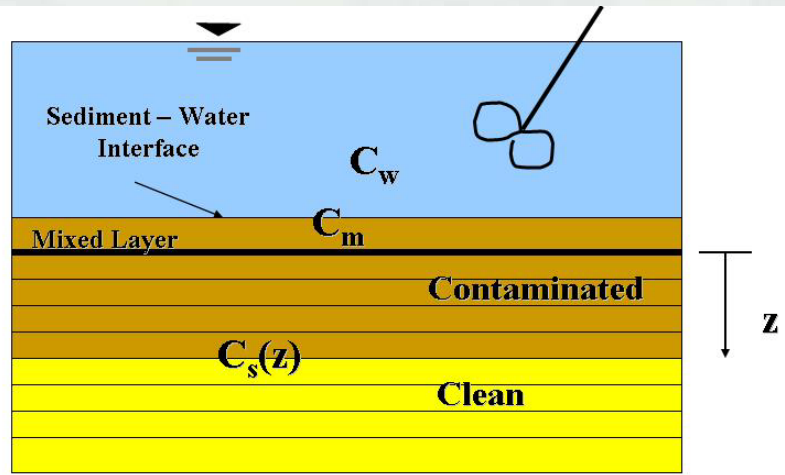
**Don't need to model  
vadose zone for  
steady-state**



**Single Well Location**



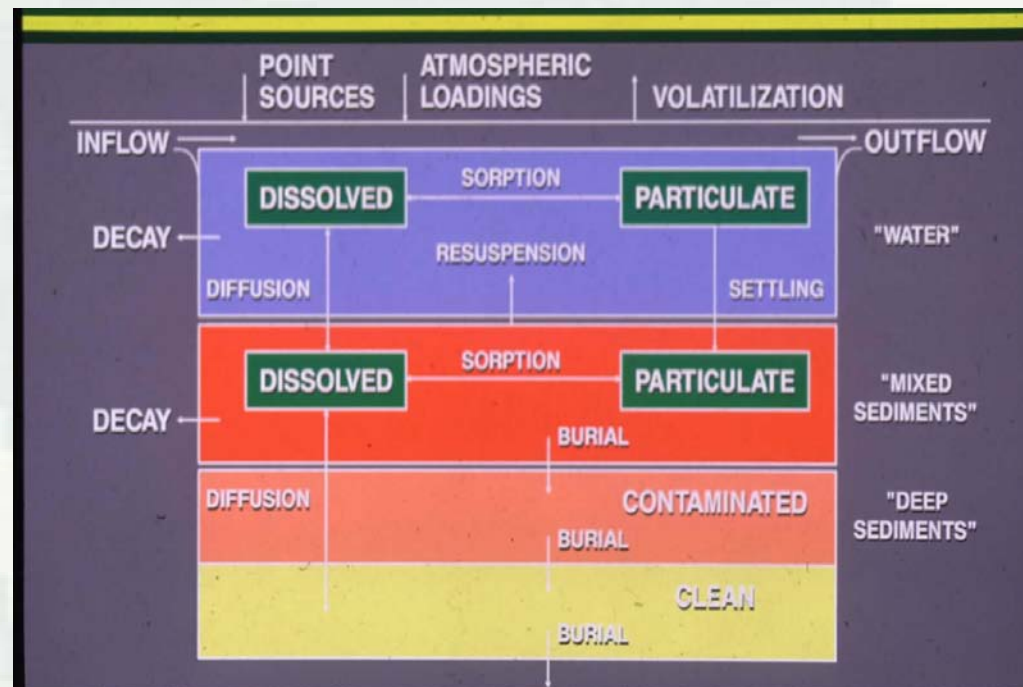
# ***Tier 1 Surface Water Model (RECOVERY with fewer inputs – prescribed inputs)***



## **Model conceptualization**

**MC runoff/erosion dumps directly into surface water, i.e., no routing or in-path storage**

## **Model fate processes**



## Tier 2 Conceptual Model

**Munitions Residue Mass Loading**

**Degradation and Volatilization**

**Soil Concentration**

**Soil Source Zone, AOI**  
solid and non-solid phase mass

**Erosion/Runoff mass flux**

**Interflow**

**Surface Water**

**Infiltration mass flux**

**Vadose Zone**

**Percolation mass flux**

**Groundwater mass flux to surface water**

**Surface water & sediment concentrations**

**Aquifer**

**Groundwater concentration**

**Benchmarks**

Soil model includes dissolution kinetics





## ***Tier 2 Model Primary Assumptions***

- Area of Interest (AOI) is homogeneous
- Inputs and model responses are time-varying
- There can be fate losses, such as degradation (1<sup>st</sup> order)
- Sorption is linear, reversible equilibrium
- Solid and non-solid phase mass are tracked with dissolution
- No losses between the AOI and receiving surface water for runoff/erosion and interflow
- Steady-state hydrologic inputs (average annual conditions) like Tier 1
- Vadose transport is 1D vertical

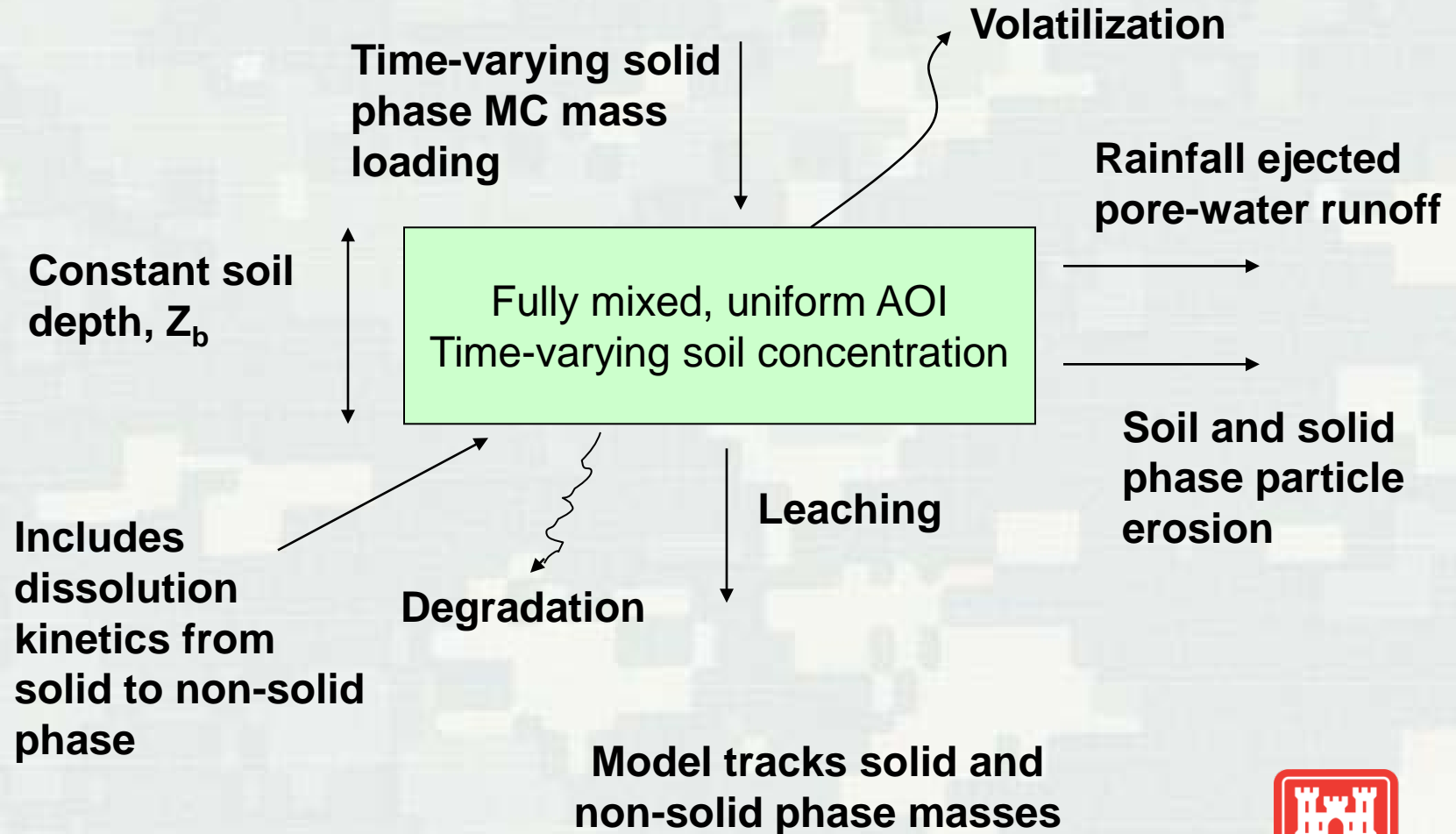


## ***Tier 2 Modules***

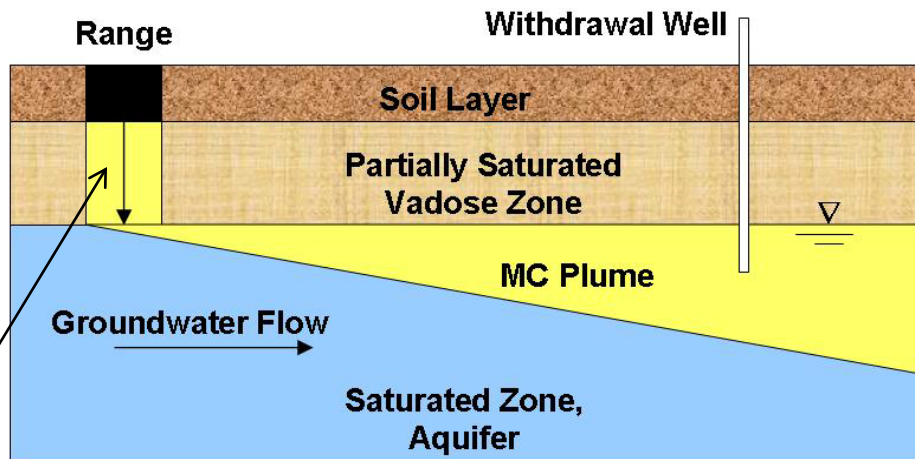
- Same as Tier 1 except for the following additions:
  - ▶ Tier 2 soil model is used instead of Tier 1 soil model
  - ▶ MEPAS Vadose Zone model and flux viewer
  - ▶ Contaminant Model for Streams (CMS); user must choose whether to use CMS or RECOVERY for surface water and sediments (default is RECOVERY)
  - ▶ Sensitivity and Uncertainty (S/U) based on Monte Carlo simulation with Latin Hypercube sampling
  - ▶ S/U viewers
  - ▶ Plus-SG Operator: allows aquifer discharge to surface water; transparent to user other than having to specify the aquifer discharge rate to surface water



# ***Tier 2 Soil Model***



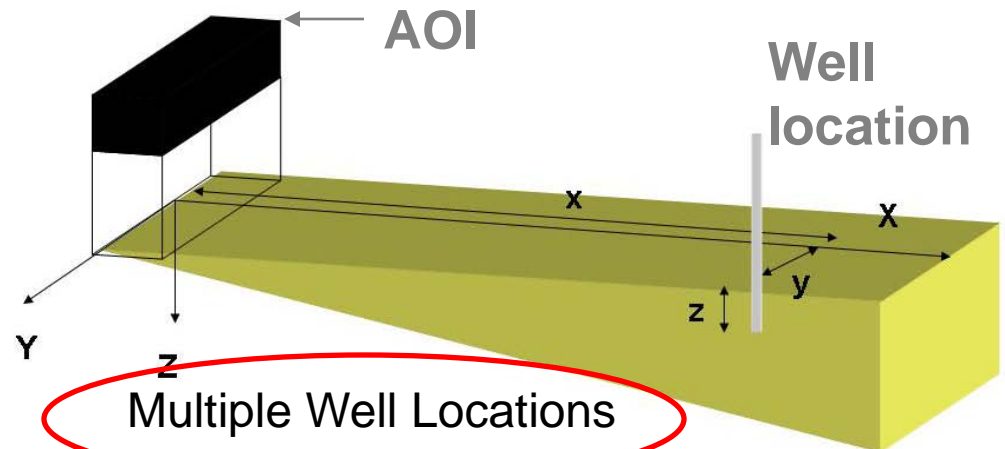
# ***MEPAS Vadose & Aquifer Models for Tier 2 with full Capabilities***



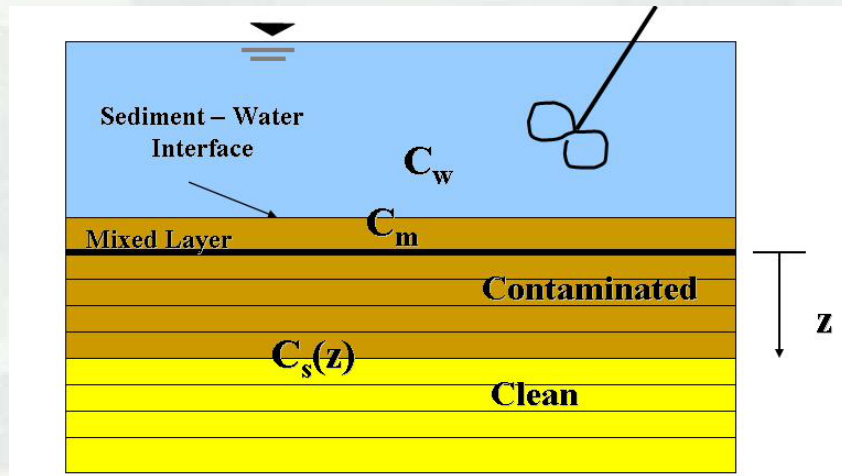
**AOI length and  
width are input in  
Soil MUI**

**MEPAS coordinates**

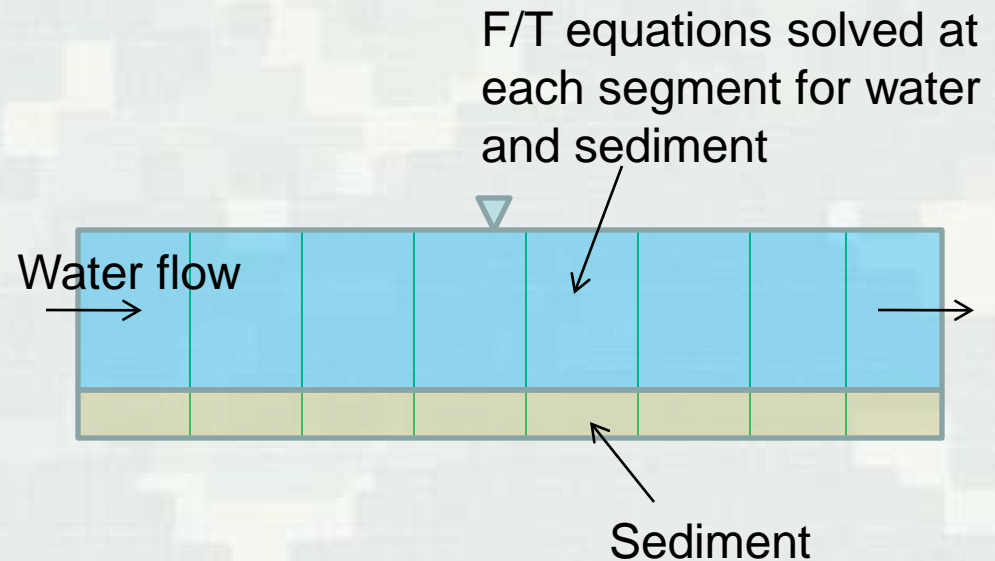
Vadose Zone  
included



# ***Tier 2 Surface Water Models, RECOVERY and CMS with full Capabilities***



**RECOVERY Model conceptualization**



**CMS conceptualization**



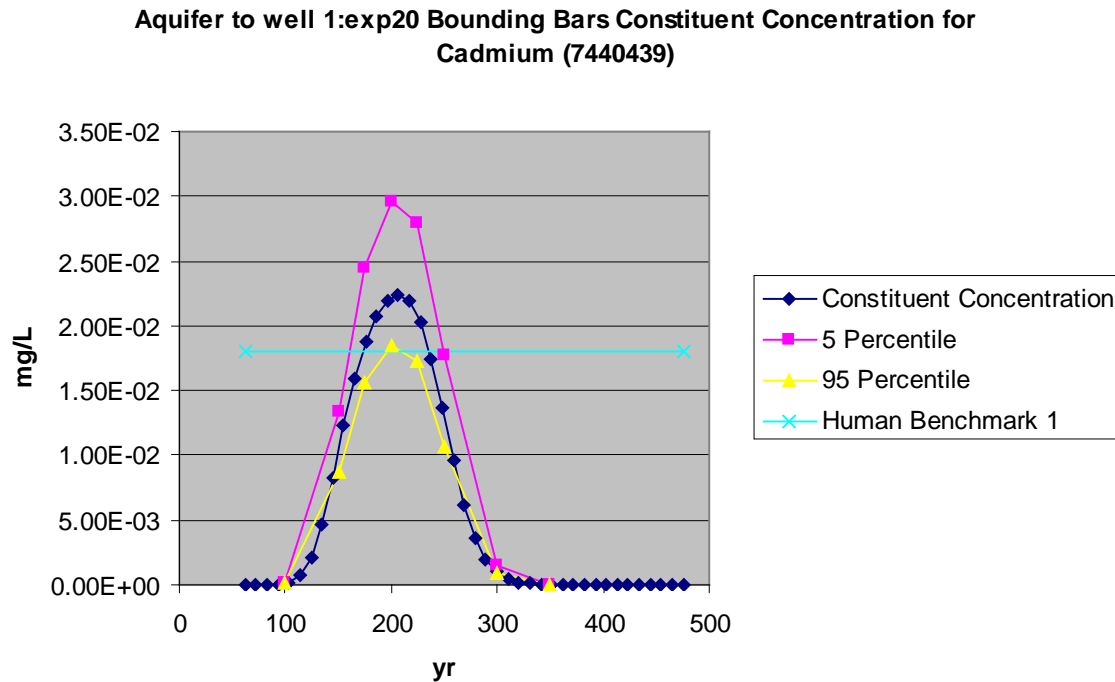
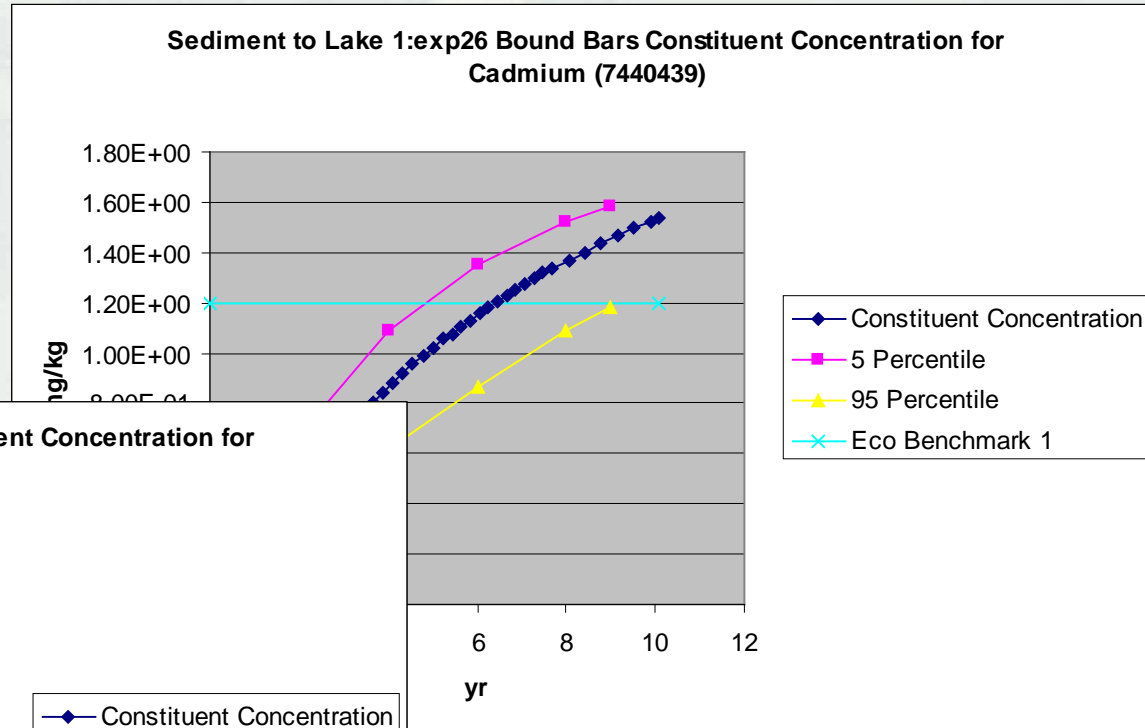
# ***Sensitivity/Uncertainty Module***

- Declare uncertain parameters
- Declare variables and their features to watch for output, e.g., aquifer concentration at specific years or peak concentration for simulation
- Specify the type of distribution and its statistics for each uncertain parameter, e.g., normal distribution with mean, upper and lower bounds, and standard deviation
- Set random seed and number of Monte Carlo iterations



# S/U Example Output Viewer

Concentration versus time  
with confidence limits



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# ***TREECS Status***

- Currently being tested and validated using existing training range data by EL, AEC, and CHPPM personnel
- Used to help support ORAP Phase II Assessments
- FY11-FY13 – Further enhancements to Tier 1 and Tier 2 modeling capabilities and database expansions
- FY11-FY13 – Development and Implementation of a Fully Explicit Physically Based Watershed Modeling capability within the TREECS Framework – *Useful for evaluating mitigation scenarios for multiple AOIs covering complex terrain*



# *Questions?*



<http://el.erdc.usace.army.mil/treecs/>

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